Szekely, Peter

From: Releford, Carol
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Hi Peter,

Here's copies of the Translations that you requested. For S/N 09/902,064. Paper copies of these Translations along with your copies of the Patents are ready for pick-up in the Translations Branch.

Thanks,

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METHOD FOR MANUFACTURING FIBER-REINFORCED CEMENT PLATE
[SEN'I HOKYO SEMENTO NO SEIZO HOHO]

Nobuo Inui, et al.

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INVENTOR	(72):	INUI; NOBUO, ET AL.
APPLICANT	(71):	KUBOTA LTD.
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Specifications /117*

1. Title of the Invention

Method for Manufacturing Fiber-Reinforced Cement Plate

2. Claim(s)

(1) A method for manufacturing a fiber-reinforced cement plate characterized by making a raw material slurry, containing, of the total content, 3 to 10 wt.%, and preferably, 6 to 8 wt.% asbestos, 0 to 7 wt.%, and preferably 4 to 6 wt.% pulp (with the total amount of the pulp and asbestos being 10 wt.% or more of the total content), 0.5 to 2 wt.% high tensile strength organic synthetic fibers with a tensile strength of 9 g/dr or higher and a coefficient of extension of 5 to 10%, and a balance of cement.

(2) The method for manufacturing a fiber-reinforced cement plate of claim 1 wherein the fineness of the high tensile strength organic synthetic fibers is 15 to 25 denier.

(3) The method for manufacturing a fiber-reinforced cement plate of claim 1 or 2 wherein the length of the high tensile strength organic synthetic fibers is 5 to 25 mm.

(4) The method for manufacturing a fiber-reinforced cement plate of any of Claims 1 to 3 wherein the slurry is obtained by mixing and agitating the asbestos and high tensile strength organic synthetic fibers in advance and then mixing and agitating this with the pulp, cement and water.

(5) The method for manufacturing a fiber-reinforced cement plate of Claim 4 wherein the mixing and agitating of the asbestos and high tensile

* Number in margin indicates pagination in the foreign text.

strength organic synthetic fibers is performed with willow.

(6) The method for manufacturing a fiber-reinforced cement plate of any of Claims 1 to 5 wherein the cement is a mixture of an expander mixed with an equal amount of Portland cement or less.

3. Detailed Specifications

This present invention relates to a method for manufacturing a cement plate reinforced with organic synthetic fibers.

As is well known, cement moldings are poor in tensile strength and impact strength; hence, it is necessary to reinforce them with fibers when they are used as plates for construction.

A typical fiber-reinforced cement plate is an asbestos fiber-reinforced cement plate. Class 4, 5 and 6 asbestos are used for the asbestos in this asbestos fiber-reinforced cement plate, and the amount added /118 thereof is 15 to 25% of the total amount. The bending strength of the asbestos fiber-reinforced cement plate corresponding to this added amount is 200 to 300 kg/cm^2.

Incidentally, the majority of the domestic demand for asbestos is dependent on imports. However, the availability of asbestos has become noticeably difficult recently as worldwide asbestos sources are being exhausted. The status quo is that reinforcing fibers are in demand to take the place of asbestos fibers because the mechanical strength of asbestos fibers is not that superior, etc.

It has been known in the past that cement products were reinforced with synthetic fibers. But these synthetic fibers were mostly helpful for preventing hairline cracks in the cement molding. It has been clearly

proven experimentally that they do not serve to improve the bending strength of cement moldings.

As a rule, the mechanism for strengthening cement moldings with fibers cannot be discussed unconditionally, but it can be explained roughly as follows.

Now when a tensile force acts on fiber-reinforced cement material, the majority of the tensile force thereof is shared by the fibers. In this case, if the cross section of the fibers is $\mathbf{S_1}$, the Young's modulus of the fibers is $\mathbf{E_1}$, the section of the cement matrix is $\mathbf{S_2}$, the Young's modulus of the cement is $\mathbf{E_2}$, and the tensile force is $\mathbf{F}$, the tensile force $\mathbf{X}$ acting on the fibers is:

The smaller the ratio E_2/E_1 of the Young's modulus of the fibers and the cement, the larger the distribution rate of the tensile force on the fibers may be.

If the tensile force is shared by the fibers, as described above, the tensile force thereof acts as a shear force in the interface between the fibers and the cement. In this case, if the tensile stress acting on the fibers is δ, the shear stress acting on the interface between the fibers and the cement is τ, the fiber diameter is $\mathbf{d}$, and the fiber length is $\mathbf{l}$, then:

$$\pi d l \tau = \pi \left(\frac{d}{2}\right)^2 \delta$$

and thus

$$\delta = \frac{4 \ell \tau}{d} \qquad \text{———} \quad (2)$$

According to Equation 2, the shear stress can be sufficiently reduced in the interface between the cement and the fibers if the fiber length **l** is long enough even if the tensile stress δ of the fibers reaches the breaking strength. Therefore, the shear fracture may be prevented in this interface and the tensile strength of the fiber-reinforced cement plate may be improved over that of the fibers.

The reason the mechanism for reinforcing the tensile strength of a cement material by fibers does not improve the bending strength much, even when synthetic fibers are added to the cement material according to the explanation given above, is thought to be because the ratio E_2/E_1 of the Young's moduli of the fibers and the cement in Equation 1 is small, and not enough tensile force can be shared by the fibers.

A fiber-reinforced cement plate that uses glass fibers as the reinforcing fibers as well as vinylon fibers having a fineness of 5 to 100 denier and a fiber length of 4 to 40 mm is disclosed in Tokkai No. 49-104917.

However, the bending strength is no more than 260 kg/cm^2 when the there are 5 parts by weight of vinylon fibers, 5 parts by weight of glass fibers, 90 parts by weight of cement in this fiber-reinforced cement plate.

If the ratio E_2/E_1 of the composite Young's modulus $\mathbf{E_2}$ of the glass fibers and the cement and the Young's modulus $\mathbf{E_1}$ of the vinylon fibers is thought to be substantially high for this fiber-reinforced cement plate and considered according to Equation 1, an action for sharing the tension by the vinylon fibers cannot be anticipated at all. That is, the action

of the vinylon fibers as reinforcing fibers is not manifested at all.

Moreover, the above-mentioned fiber-reinforced cement plate disclosed in Tokkai No. 49-104917 is manufactured by mixing and kneading the glass fibers, vinylon fibers and cement with water, pouring this mixture into a wooden mold, and curing it in air under compression.

In the manufacture of organic synthetic fiber-reinforced cement plates, it is wise to use existing sheetmaking devices which are used in the manufacture of the asbestos-reinforced cement plates from the standpoint of equipment expenses. In this case, there are problems peculiar to sheetmaking methods when organic synthetic fibers are mixed in place of asbestos fibers, such as the problem of aggregation and the problem /119 of scooping up organic synthetic fibers. There are various problems in the manufacture of the fiber-reinforced cement plate disclosed in Tokkai No. 49-104917 by a sheetmaking method.

However, as a result of mixing and agitating special vinylon fibers, which are high tensile strength organic synthetic fibers with a fineness of 15 to 25 denier, a coefficient of extension of 5 to 10%, and a tensile strength of 9 to 12 g/dr, asbestos and water, making sheeting from this, and curing this sheetmaking material outdoors, the inventors of the present invention were able to obtain a fiber-reinforced cement plate with a bending strength of 300 kg/cm^2 or higher by suitably selecting the compounding ratio of the asbestos, organic synthetic fibers and cement.

For example, as a result of making a 6.0 mm thick sheet from an 8% concentrated slurry comprising raw materials, i.e., 10 wt.% of 10 mm long high tensile strength organic synthetic fibers with a 15 denier fineness,

10 wt.% of asbestos and 89 wt.% of cement by means of an ordinary wet machine, subjecting this original plate for sheetmaking to compression molding for 3 minutes at 80 kg/cm^2, and curing it outdoors, the bending strength on the 7th and 14th day after the start of curing was 310 kg/cm^2 and 360 kg/cm^2, respectively.

The ratio E_2/E_1 of the composite Young's modulus $\mathbf{E_2}$ of the glass fibers and the cement and the Young's modulus $\mathbf{E_1}$ of the vinylon fibers in a prototype of the above-mentioned fiber-reinforced cement plate developed by the inventors of the present invention is small, and as seen by Equation 1, the tensile force shared by the high tensile strength organic synthetic fibers would be high. Therefore, the high tensile strength organic synthetic fibers act effectively as a reinforcing member. The above-mentioned superior bending strength is considered to be manifested as a result of this.

The method for manufacturing the fiber-reinforced cement plate pertaining to the present invention was explained on the basis of experimental findings in which an organic synthetic fiber-reinforced cement plate having a superior bending strength, as described above, and also superior impact resistance performance and high deflection may be obtained if the aforementioned organic synthetic fibers, such as special vinylon fibers, and asbestos fibers are combined at a specific ratio and subjected to sheetmaking. This is a method which eliminates the described problems of the organic synthetic fibers at the time of sheetmaking, and at the same time, is capable of industrially producing an organic synthetic fiber-reinforced cement plate having superior bending strength and impact

resistance and a high deflection.

That is, the method for manufacturing a fiber-reinforced cement plate pertaining to the present invention is a method characterized by making a raw material slurry, containing, of the total content, 3 to 10 wt.%, and preferably, 6 to 8 wt.% asbestos, 0 to 7 wt.%, and preferably 4 to 6 wt.% pulp (with the total amount of the pulp and asbestos being 10 wt.% or more of the total content), 0.5 to 2 wt.% high tensile strength organic synthetic fibers with a tensile strength of 9 g/dr or higher and a coefficient of extension of 5 to 10%, and a balance of cement.

The fineness and length of the high tensile strength organic synthetic fibers used in the present invention are 2 to 25 denier and 2 to 25 mm, respectively.

It is unfavorable if the fineness is greater than 25 denier because the elongation becomes high, the aforementioned Young's modulus becomes small, and the degree of sharing of the tensile force by the organic synthetic fibers, which was explained according to the described Equation 1. If the fineness is less than 2 denier, the yield point of the organic synthetic fibers is reduced and the tensile strength is poor.

Moreover, it is unfavorable if the fiber length is less than 5 mm because the tensile stress acting on the fibers explained according to described Equation 2 previously may not be high enough. If it is higher than 25 mm, aggregation of the organic synthetic fibers which will be described later becomes marked, which is unfavorable for mixing organic synthetic fibers in a short length of time.

The above-mentioned ratio of the organic synthetic fibers, asbestos, pulp and cement is selected so that a bending strength of 200 to 300 kg/cm^2 can be ensured for the fiber-reinforced cement plate to be obtained in the end.

This bending strength varies due to many factors, such as the mechanical properties, length, and fineness of the organic synthetic fibers, the composite mechanical properties of the asbestos, pulp and cement, etc., as interpreted from the described Equations 1 and 2 previously.

The reason for adding the pulp, as needed, in the present invention is to distribute the sawing and nailing properties, etc. The reason for limiting the amount of pulp added to 7 wt.% or less is because the /120
bending strength is reduced if it is 7 wt.% or less.

The reason for limiting the amount of the asbestos added to 3 to 10 wt.% and the amount of the organic synthetic fibers added to 0.5 to 2 wt.% is to ensure a bending strength of 250 to 300 kg/cm^2. If the amount of asbestos is less than 3 wt.% and the amount of organic synthetic fibers is less than 0.5 wt.%, this strength cannot be ensured. If the amount of organic synthetic fibers is higher than 2 wt.% and that of asbestos is higher than 10 wt.%, the bending strength is higher than 300 kg/cm^2.

The reason for limiting the total amount of the asbestos and pulp to 10 wt.% or higher is to increase the scooping up rate of the solid content besides the cement and ensure dispersibility of the organic synthetic fibers. Furthermore, the concentration of filtered water is reduced and also the sheetmaking property is excellent if 0.003 to 0.06% of an organic polymer flocculant is added, with respect to the solid.

In the present invention, it is preferable to charge the willow with the organic synthetic fibers while the asbestos is subjected to fiberizing with the willow, and mix and agitate the asbestos and organic synthetic fibers in advance. Hence, the organic synthetic fibers can be dispersed uniformly by shortening the agitation time when the slurry is mixed and agitated.

In the present invention, a cement in which an equal wt.% or less of expander, such as silica sand, is mixed with Portland cement can be used as the cement. By using a natural or man-made lightweight aggregate, such as Shirasu balloons, lapilli, and expanded clay ["clay" misspelled in source], the processability, such as sawing and nailing, is improved. Hence, lower cement costs can be planned, and a reduction in the bending strength can be halted within 8% as compared to when only Portland cement is contained.

In the present invention, special advantages from using the organic synthetic fibers as the reinforcing fibers can be cited. Although chemical bonding between the glass fibers and the matrix cannot be avoided and the deflection of the plate material becomes small when glass fibers or the like, which are inorganic fibers, are used, the chemical bonding mentioned above does not occur and the deflection is reduced remarkably in the case of organic synthetic fibers.

The practical examples of the present invention are explained next.

A basic method used in each practical example is as follows.

A slurry of a prescribed concentration is obtained by mixing and agitating the high tensile strength vinylon fibers and asbestos fibers,

and then this mixture is mixed with the pulp and cement and agitated with a prescribed amount of water in a pulper. This slurry is supplied to the vat of a wet machine, subjected to sheetmaking through a 60 mesh round sieve cylinder, the thin sheet-making film is transported on a felt belt and the thin film on the felt belt is taken up by a making roll. The thickness of the thin sheet-making film is 0.5 mm. The moisture content of the thin film thereof is adjusted to 25% by suction on the front side of the making roll. If the taking-up thickness of the making roll reaches 6 mm, the taken-up material is cut open and peeled from the making roll, and press-molded at an average pressure of 80 kg/cm^2. The molding is cured spontaneously by outdoor exposure.

Practical Example 1.

A 5% concentrated slurry comprising 0.6 wt.% of high tensile strength vinylon fibers (length: 10 mm, fineness: 15 dr; trade name: VPM 150 2×10 mm and available from Kuraray Co., Ltd.), 0.8 wt.% of regenerated pulp, 10 wt.% of asbestos (class 6 chrysotile asbestos according to the criteria of JIS-A-5403), and 87.9% of cement (Portland cement according to the criteria of JIS-R-5210) was produced in a standard method and this was made into sheeting in a standard method.

Practical Example 2.

A 9% concentrated slurry comprising 1.0 wt.% of high tensile strength vinylon fibers (length: 10 mm, fineness: 20 dr; trade name: KB20 and available from Kuraray Co., Ltd.), 5.0 wt.% of the above-mentioned regenerated pulp, 7.0 wt.% of the above-mentioned asbestos, and 87% of the above-mentioned cement was produced in a standard method and this was made into sheeting

in a standard method.

Practical Example 3.

A 5% concentrated slurry comprising 1.0 wt.% high tensile strength vinylon fibers (length: 10 mm, fineness: 15 dr; trade name: VF1203-2 and available from Kuraray Co., Ltd.), 5.0 wt.% of the above-mentioned regenerated pulp, 7.0 wt.% of the above-mentioned asbestos, and 87% of cement (47 wt.% of Portland cement and 40 wt.% of silica sand) was produced in a standard method and this was made into sheeting in a standard method.

No aggregation of the high tensile vinylon fibers was seen while mixing and agitating the slurry in any of the above-mentioned practical examples. Moreover, the concentration of the filtered water was 0.7% or less in any of the practical examples, and the sheetmaking efficiency also was excellent.

The original plates obtained in the practical examples 1 to 3 were cured spontaneously by exposure outdoors, and as a result of /121 measuring the bending strength, deflection and Charpy impact on the 4th, 7th and 14th day as well as 1 month after curing started, the values were as given below.

Bending Strength (kg/cm^2)

	Day 4	Day 7	Day 14	1 month
Practical Example Product 1	310	330	300	300
Practical Example Product 2	270	280	270	260
Practical Example Product 3	270	260	260	270

Charpy Impact ($kg\text{-}cm/cm^2$)

	Day 4	Day 7	Day 14	1 month
Practical Example Product 1	6.0	6.1	5.7	5.5
Practical Example Product 2	8.3	8.4	7.6	7.0
Practical Example Product 3	7.0	7.0	6.9	6.7

Deflection mm (provided the span is 40 cm)

	Day 4	Day 7	Day 14	1 month
Practical Example Product 1	17.3	17.9	17.2	16.9
Practical Example Product 2	12.0	11.3	11.1	10.3
Practical Example Product 3	20.1	16.4	15.9	14.6

As seen from the above-mentioned value, according to the present invention, organic synthetic fiber-reinforced cement plates with bending strengths of 250 to 300 kg/cm^2 and high impact resistance can be manufactured industrially by an existing sheetmaking device.